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/SUMMARY/

HYDRODYNAMICAL EQUATIONS OF A SUPERCONDUCTING FLUID

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The behavior, at absolute zero, of an electron fluid without viscosity is examined. Introducing the Lorentz force, the hydrodynamical equations of motion using the Eulerian equations are set up. These lead to the nonlinear equation

$$\dot{\vec{V}} = (e/m)\,\vec{E} - \mathrm{grad}\,(V^2/2 + h), \qquad (1)$$

in place of the London acceleration equation, and to the time derivative of the curl equation

$$\mathrm{curl}\,\dot{\vec{V}} + (e/mc)\,\dot{\vec{B}} = 0, \qquad (2)$$

in place of the second London equation, in agreement with the fact that superconductivity is not merely perfect conductivity (here, h is the enthalpy per unit mass, and the other symbols have their customary meanings). The curl equation of the London theory

$$\mathrm{curl}\,\vec{V} + (e/mc)\,\vec{B} = 0 \qquad (3)$$

does not follow simply from the condition of zero viscosity of the fluid. Equation (3) involves a condition more stringent than zero viscosity. This condition is expressed by saying that there can be no "internal motion" of the system; this corresponds to a reduction in the number of allowable quantum states of the system, as has been pointed out by F. London.

The results are discussed in the light of the variational principle of mechanics. If the Lagrangian is formed for the electron fluid, the coordinates

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of the particles are varied and one does not obtain equations [illegible] of a "superfluid." As the description of a superfluid is [illegible] velocity and density of the particles, and not of positions [illegible] variational principle must be used by varying the velocities [illegible] is carried out subject to the equation of continuity for the [illegible] varied motion and to the condition that the variations vanish at [illegible] This leads immediately to equations (1) and (3); i.e., it gives [illegible] equation immediately. The use of the variational principle in this way must therefore imply an assumption additional to that of zero viscosity.

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